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THE HUMIDITY DEPENDENCE OF THE AEROSOL SCATTERING COEFFICIENT AND ITS CONTRIBUTIONS FROM PARTICLE SIZE AND REFRACTIVE INDEX

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ABSTRACT

The primary influence on direct radiative forcing by an aerosol is its (wavelength-dependent) scattering coefficient, which depends strongly on relative humidity (RH). This humidity dependence derives from two distinct sources: primarily the increase of the geometric sizes of the aerosol particles with increasing RH, and secondarily the decrease in the index of refraction of those particles that are solution drops with increasing RH as the drops become larger and thus more dilute. Knowledge of this dependence allows measurements of aerosol scattering coefficient under controlled conditions to be extrapolated to ambient conditions, thus yielding the interaction of the aerosol with radiation in actual situations. The dependence of aerosol scattering coefficient on RH is commonly measured, and attempts have been made to use this dependence to infer the chemical composition of the aerosol. The dependence of aerosol scattering coefficient on wavelength is also commonly measured and is quantified in terms of the Ångström exponent, the negative derivative of the logarithm of the scattering coefficient with respect to the logarithm of the wavelength, which provides information on the sizes of particles that provide the dominant contribution to the scattering. The Ångström exponent increases from near 0 (larger particles) to greater than 2 (smaller particles).

The relative importance of the humidity dependences of particle size and index of refraction on the aerosol scattering coefficient for a given substance depends on RH and on the sizes of the particles that provide the dominant contribution to the scattering. For instance, for an aerosol consisting of ammonium sulfate solution drops with Ångström exponent 0, 1, or 2, respectively, the ratio of the scattering coefficients between relative humidities 40% and 80% increases from 1.6 to 1.8 to 2.1. This increase is due to the growth of smaller particles to sizes at which they scatter more light being more pronounced than that for larger particles. Here we present an expression for the ratio of the aerosol scattering coefficient at two relative humidities in terms of the hygroscopic growth factor for particle diameter and the Ångström exponent, from which the relative importance of the size effect and the index effect can be explicitly determined.

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